NASA Commercial Programs

A Progress Report 1989

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NASA's Office of Commercial Programs:
Providing a Focus for Action

Space has become an economic frontier, a new territory of commercial competition, where the spacefaring nations of the world seek new opportunities for industrial growth and economic benefit.

In 1984, the United States Congress amended the 1958 Space Act to assign the National Aeronautics and Space Administration an important new mission: "... seek and encourage, to the maximum extent possible, the fullest commercial use of space."

President Bush, in his first presidential address to a joint session of Congress, sounded strong support for this national goal when he called for "more commercial development of space."

NASA's Office of Commercial Programs is providing a focus for action to stimulate and assist an expanded involvement and investment by the U.S. private sector in civil space activities.

Strengthened by a rich tradition of NASA cooperation with industry, the office supports new high-technology commercial space ventures, the commercial application of existing aeronautics and space technology, and greater access by commercial firms to available NASA capabilities and services.

This report, prepared by the Public Affairs Office of the Office of Commercial Programs, highlights NASA-sponsored and assisted commercial space activities of the past year.

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To our shareholders:

James T. Rose

As we observe the 20th anniversary of America's first lunar landing this year, it is important to recognize that our nation's space enterprise has paid "dividends" to every citizen.

Those benefits have come in the form of technological advances, improvements in the quality of our lives here on Earth, and in far-reaching positive impacts on our national economy.

Through cooperative efforts with U.S. industry to commercially develop space and accelerate the commercial application of space technologies, NASA seeks to expand the economic returns from our public investment.

During 1989, we made significant progress in defining an overall program of commercial space development. We have categorized and scoped the different types of commercial space activities, assessed the unique requirements and issues affecting the growth of each, and developed mechanisms to carry out a comprehensive and aggressive program.

We witnessed this year the re-emergence of an active flight program of industrial research and development experiments in space. These industry investigations into the practical commercial uses of space represent a growing interest by the U.S. private sector, stimulated and encouraged by NASA- sponsored programs.

There is an increasing recognition, both in the U.S. and abroad, that space has attributes that are of great value. These resources and characteristics will play a major role in opening a new economic frontier for the spacefaring nations of the world.

It is clear then that commercial development is both a logical next step in America's civil space efforts and a prudent competitive strategy.

Our challenge is to organize these efforts into a program that develops commercial space markets, low-cost commercial space transportation systems, and a commercial space infrastructure industry.

The rewards of our success will be significant contributions to America's future industrial competitiveness, and the maximum economic returns to our stockholders — the American people.

James T. Rose

JAMES T. ROSE
NASA Assistant Administrator
for Commercial Programs

1989: Establishing a Strategic Vision

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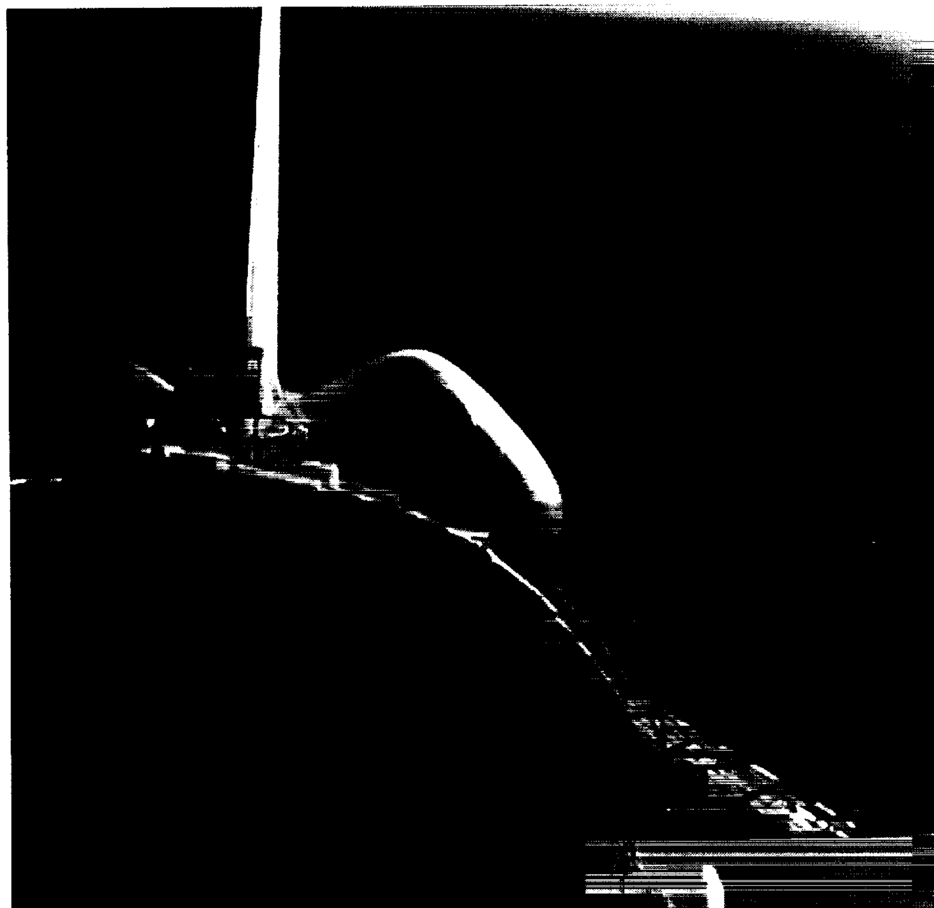
Amid a dramatic growth of activity and interest in the commercial development of space, NASA's Office of Commercial Programs (OCP) focused in 1989 on the establishment of a strategic vision.

Several key initiatives carried out during the year will culminate in a strategic plan, founded in national space policy goals for expanding U.S. space commercial activity.

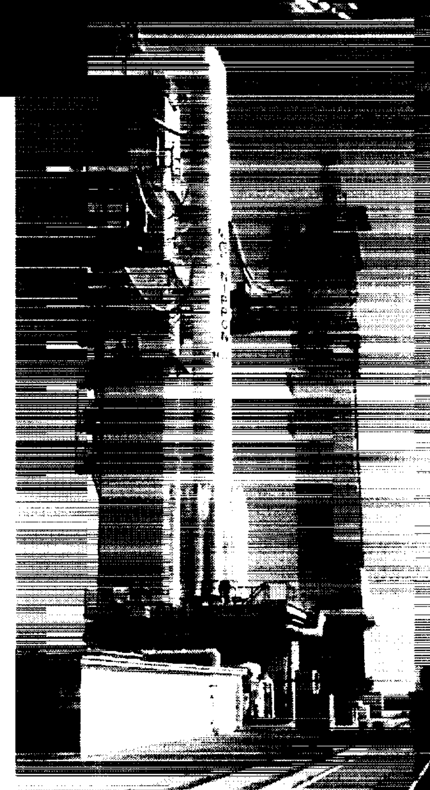
The need for a strategic vision, and a plan for realizing its goals, is clear.

Space harbors valuable resources that represent a new economic frontier for the spacefaring nations of the world. The commercial development of space is both a logical next step and a prudent competitive strategy.

In Europe and Japan, our increasingly space-capable trading partners have identified the attributes of Earth orbit as having significant potential for producing new high-technology products and services with global markets. Foreign firms operate with a high level of direct and indirect government support, enhancing their competitive position.



Above: Space Shuttle orbiter, outfitted with the European-built *Spacelab* orbital laboratory, enables the exploration of the unique attributes of space. Right: West German payload specialist conducts experiments aboard *Spacelab* in the U.S. Space Shuttle during a mission purchased by the Federal Republic of Germany.



Japanese development of the H-1 rocket is indicative of increasing capability and interest in the industrial uses of space.

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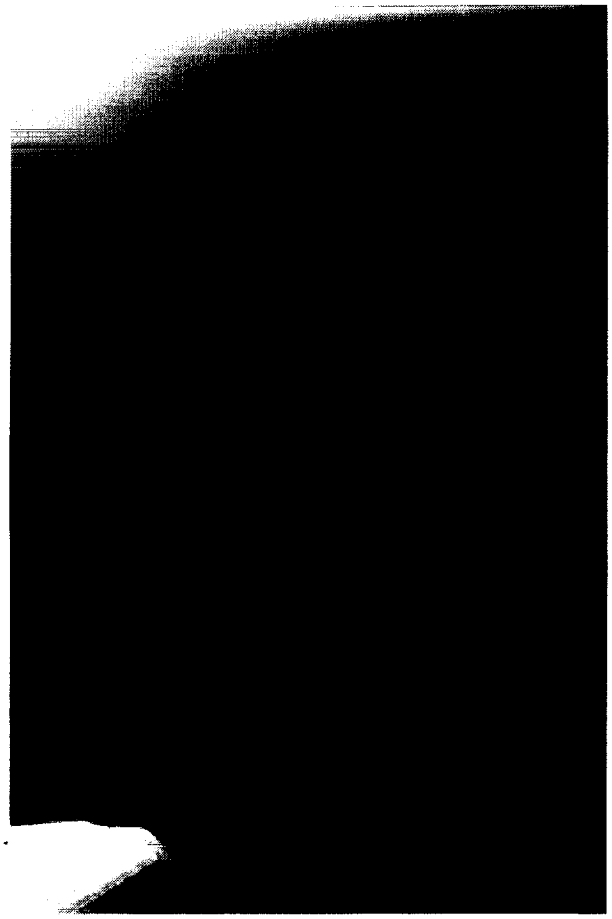

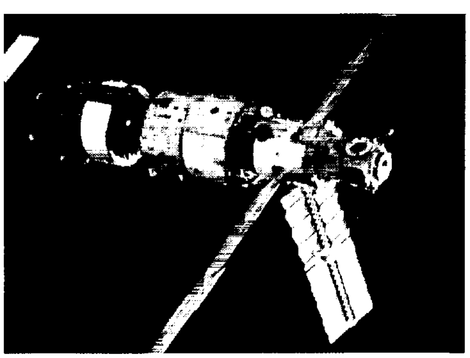

Glavkosmos, the Soviet Union's commercial space marketing organization, is offering opportunities for use of the *Mir* space station.

Other space powers, notably the Soviet Union and China, have become aggressive marketers of space transportation and related services, seeking to attract foreign currency into their economies.

Between 1984 and 1988, President Reagan and the U.S. Congress, recognizing the importance of a policy framework that would foster American leadership in the economic development of space, took the first major steps to focus federal action on an expanded role for the U.S. private sector in the nation's civil space program.

These actions included an amendment to the 1958 Space Act that directed NASA to "seek and encourage, to the maximum extent feasible" the commercial use of space, and the incorporation of commercial space initiatives into the administration's national space policy.

Early in his term, President Bush signaled a continued emphasis on the economic importance of space commercial development.

Based on major efforts this year to identify key issues, define appropriate relationships between government and industry, and chart a course toward U.S. preeminence in space commerce, the Office of Commercial Programs' strategic planning has three key goals:

- Actively fostering the development of space-related markets.
- Improving the availability of and access to transportation and infrastructure to support emerging markets and new ventures.
- Using NASA resources to support the development and growth of successful commercial space ventures.

"We must have a manned space station, a vigorous, safe Space Shuttle program, and more commercial development of space."

— President Bush addressing Joint Session of Congress

Seeking U.S. Space Industrial Competitiveness

The Commercial Programs Advisory Committee (CPAC), a distinguished panel of industry chief executive officers and their university counterparts, serving as a standing committee of the NASA Advisory Council, issued this year its first formal recommendations, embodied in a report entitled *Charting the Course: U.S. Space Enterprise and Space Industrial Competitiveness.*

The CPAC was established in 1988 through the initiative of NASA Assistant Administrator for Commercial Programs James T. Rose. Chaired by Edward Donley, Chairman, Executive Committee, Air Products and Chemicals, Inc., the CPAC undertook a thorough review of commercial space issues, and formulated a series of key recommendations for consideration by the nation's leaders.

These recommendations, most addressing critical policy issues, and the continuing input from the CPAC, are helping to shape the commercial development strategic plan.

Also supporting the OCP's strategic planning effort was a study conducted this year by

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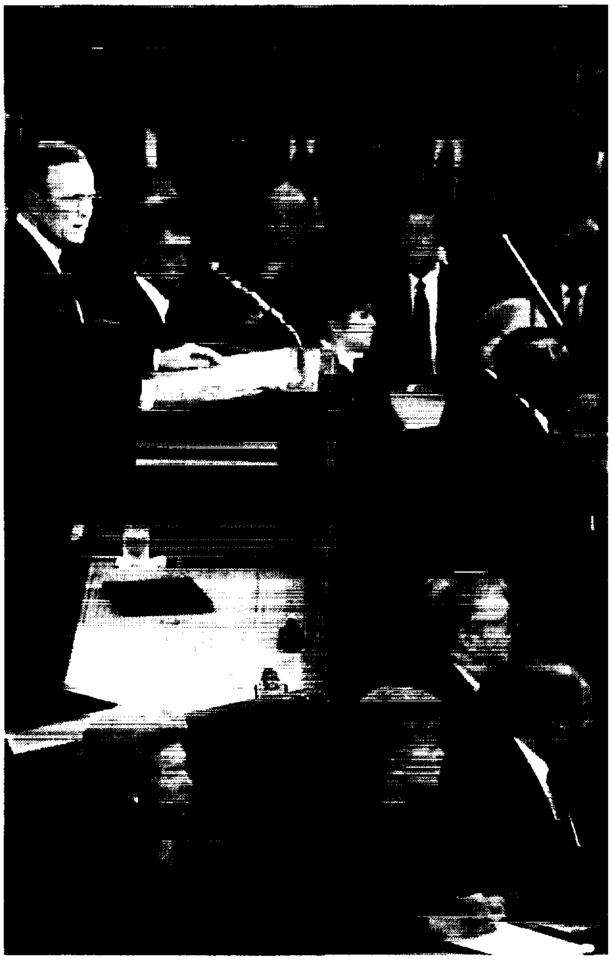


the American Institute of Aeronautics and Astronautics (AIAA) to lay groundwork for the strategic plan by defining issues and potential objectives associated with the commercial development of space.

The AIAA formed a steering committee consisting of senior-level private sector managers. The resulting study document, *Issues in Strategic Planning for Commercial Space Growth,* represents inputs from more than 90 industry representatives.

The AIAA study addresses overall goals and objectives, the scope of commercial space activities, and the roles of industry, academia, and government. It also explores issues and barriers, and suggests federal actions and policy changes.

New Analysis Capabilities and Policy Guidelines

OCP's Plans, Policy, and Evaluation Division, which coordinated and supported the 1989 strategic planning activities, also established this year a financial and business analysis function and managed the development of commercial space infrastructure policy guidelines.

With the continuing growth of the commercial space sector, and increasing competition for limited resources, the new financial and business analysis capability provides information to help NASA decision-makers in their review of candidate commercial ventures.

Commercial space infrastructure guidelines issued this year are intended to provide a framework to encourage U.S. commercial investment and involvement in NASA's space and technology programs.

Commercial space infrastructure is that portion of space infrastructure — the facilities, services, and systems that enable space activities — in which the private sector retains a permanent interest and responsibility.

The OCP also established procedures and criteria to guide NASA's orderly, timely, and equitable evaluation of commercially initiated proposals for infrastructure systems or services.

Industrial R&D in Space

A resurgence of industrial research and development activity in space took place this year following the successful return of the Space Shuttle to flight operations in September 1988.

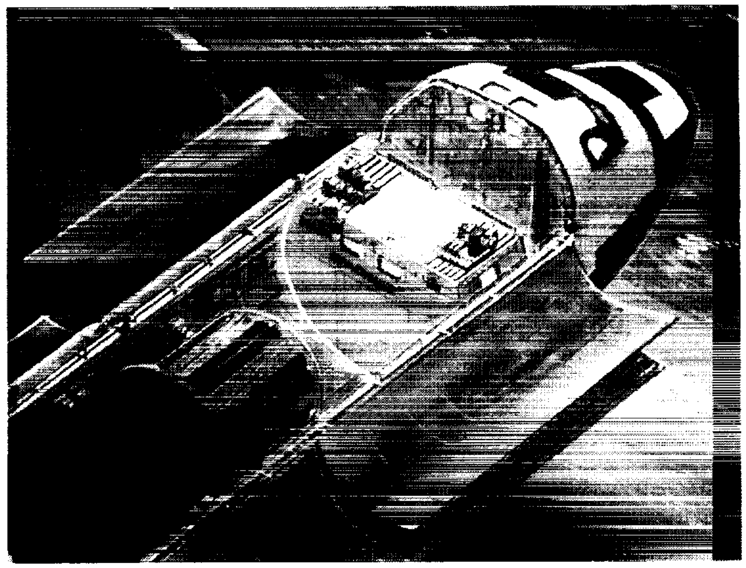
The flight of STS-26 included the involvement of several U.S. pharmaceutical companies in an investigation of protein crystal growth and a 3M experiment in organic thin films.

In 1989, the Office of Commercial Programs sponsored commercial development payloads on two more Space Shuttle flights and funded the first U.S. commercial launch of a materials science payload.

The Commercial Development Division focused on supporting the growth of industry payloads stemming from increased demand for flight opportunities.

The division has projected a total of 12 commercial payload flights through FY 1990 for launch aboard the Space Shuttle and commercial sounding rockets. Four of these payloads are manifested through March 1990. Another 22 payloads are projected for flight opportunities in the 1991 timeframe.

Most of this commercial interest is directed towards focused or applied research in the



Left: SPACEHAB, Inc., is constructing pressurized research modules to fly in the Shuttle cargo bay. These modules will provide expanded opportunities for commercial users. The firm will lease volume to experimenters and pay NASA for launch costs under a Space Systems Development Agreement (SSDA). SPACEHAB's first flight is manifested for early 1992.

Right: Astronaut George "Pinky" Nelson operates 3M's experiment in organic thin films on mission STS-26. Flying for the second time under 3M's Joint Endeavor Agreement with NASA, the industrial research equipment produced thin film samples during a 1985 Shuttle mission. 3M has obtained a patent on a new material discovered in the investigation.

Liftoff of Space Service Inc.'s Starfire rocket on March 29 marked the first federally licensed commercial launch. After a brief suborbital flight providing about seven minutes of microgravity, the payload of materials science experiments was recovered.

behavior and processing of materials in the microgravity environment of space. The industry demand also reflects commercial interest in privately developed space infrastructure and support services and in commercial Earth observations.

In an effort to match space transportation and support capabilities with the anticipated growth in industry requirements, the Commercial Development Division in 1989 initiated grant funding for a commercial sounding rocket program.

The division also identified the need for the commercially provided *Spacehab* module as a carrier for NASA-sponsored industry payloads and discussions were initiated for NASA's use of *Spacehab*, scheduled to make its first flight in 1992.

The 1989 spaceflight activity sponsored by the Office of Commercial Programs consisted of:

1) Another flight of protein crystal growth experiments aboard the Space Shuttle *Discovery* in March. These experiments, coupled with those performed on STS-26, produced clear evidence that microgravity enables the manufacture of superior crystals.

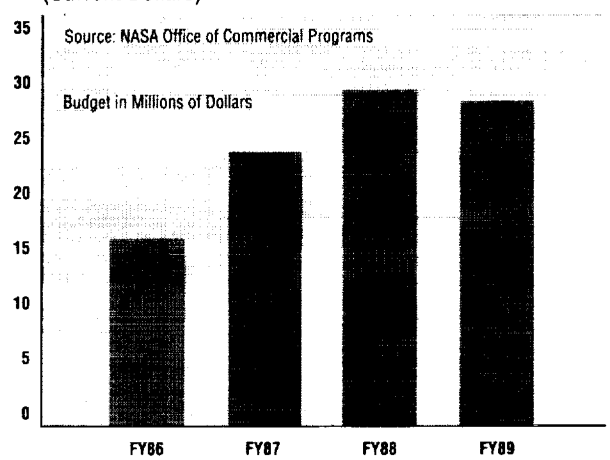
Protein crystals made in space may help to significantly advance medical research into new treatments for cancer, rheumatoid arthritis, high blood pressure, AIDS, and other diseases.

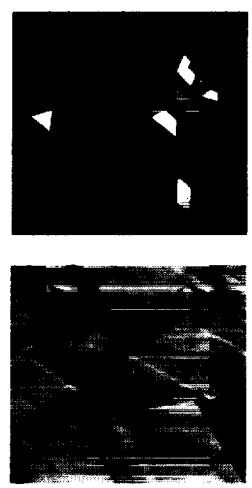
The experiments were conducted by scientists at the Center for Macromolecular Crystallography, a NASA Center for Commercial Development of Space (CCDS) at the University of Alabama–Birmingham, in collaboration with industrial researchers representing eight leading U.S. pharmaceutical companies.

2) An experiment in the space processing of indium conducted aboard the Shuttle *Atlantis* in April. This research was performed in Rockwell International's Fluid Experiments Apparatus (FEA) flown under a Joint Endeavor Agreement with NASA. Collaborating with Rockwell in the investigation was the Indium Corporation of America, exploring through microgravity research the prospects of obtaining higher purity indium.

3) The March 29 launch of materials processing experiments developed by the Consortium for Materials Development in Space, a NASA CCDS at the University of Alabama–Huntsville, aboard Space Services, Inc.'s, Starfire rocket at White Sands Missile Range, New Mexico. The suborbital flight, which provided seven minutes of microgravity, represented the first federally licensed commercial launch.

OCP Budget for the Commercial Use of Space
(Current Dollars)





Protein crystals grown aboard the Space Shuttle have helped investigators determine that better-formed crystals can be grown in microgravity, as demonstrated by the photos of space-grown (top), and ground-grown crystals. Improved protein crystals may prove to be of great benefit to medical researchers seeking to develop new drug treatments for cancer, high blood pressure, emphysema, and other diseases.

In collaboration with its industry partners, the Consortium for Materials Development prepared six experiments to investigate the manufacture of new materials in space.

4) Preparations for the flight of 3M's experiment on the effects of microgravity on polymeric materials, scheduled for flight on STS-34 in October. The flight will be 3M's fifth, and will be the first under a 10-year Joint Endeavor Agreement calling for up to 62 flight experiment opportunities.

In addition to the flight activity, industrial research and development was supported in 1989 through continued programs enabling access to NASA ground and airborne facilities for microgravity and remote sensing investigations.

These activities included cooperative agreements with U.S. firms for use of NASA drop towers at the Lewis Research Center in Cleveland, Ohio, and the Marshall Space Flight Center in Huntsville, Alabama; NASA microgravity and remote sensing research aircraft; the Earth Resources Laboratory at Stennis Space Center, near Bay St. Louis, Mississippi; and life sciences capabilities at Ames Research Center, Moffett Field, California.

CCDS Summary - 1989

CCDS	COMMERCIAL FOCUS	AFFILIATES: INDUSTRY	AFFILIATES: UNIVERSITY	AFFILIATES: GOVERNMENT
MATERIALS PROCESSING IN SPACE				
BATELLE	Electronics, Polymer, and Catalysts Applications—Aeropropulsion, Airframes and Space Structures	8	7	1
UAH	Superconductors and Electro-optical Materials—Optical Scanners, Satellite Components...	9	0	1
VANDERBILT	Metals, Alloys, Ceramics, and Glasses—Solar Dynamics, Nuclear Systems, Turbines, Nozzle Components...	7	2	3
CLARKSON	Electronics, Communications—Computers, Semiconductors...	11	4	6
HOUSTON	Thin Film Growth and Materials Purification—Electronics, Magnetic Devices, Computer Circuits...	7	0	3
SPACE STRUCTURES				
CASE WESTERN	Films, Expandable Structures—Space Structures...	8	1	2
REMOTE SENSING				
ITD SRSC	Processed Remote Sensing Information—Forestry, Fisheries, Agriculture...	12	8	5
OHIO STATE	Remote Sensing Sensor and Display Applications—Coastal Planning, Crop Stress, Mining...	9	0	3
LIFE SCIENCES				
PENN STATE	Understanding of Cell Functions for Disease Treatment—Osteoporosis, Growth System...	14	0	3
COLORADO BIOSERVE	Pharmaceutical, Health Care, or Agricultural Production	30	4	2
UAB	Crystal Growth for Use in New Pharmaceuticals or Biotechnology	11	10	4
ROBOTICS				
WISCONSIN	Automation and Robotics—Dexterous Robot Hands, Intelligent, Flexible Automated Systems...	12	3	2
ERIM	Sensor and Automated Manipulation Technology for Hazardous Environments—Nuclear Waste Clean Up, Mining...	9	1	3
SPACE POWER				
AUBURN	Alternative Commercial Space Power—Transmission Systems, Advanced Controllers...	4	4	6
TEXAS A&M	Commercial Space Power Systems—Microwave Transmission, Space Station Augmentation...	24	3	7
SPACE PROPULSION				
TENNESSEE	Alternative Space Propulsion Technologies	8	3	2
	TOTAL	**183**	**50**	**53**

Centers for the Commercial Development of Space

NASA's network of sixteen Centers for the Commercial Development of Space witnessed continued progress towards attracting significant involvement by U.S. firms in space commercial development.

The number of corporate affiliations with the CCDS centers grew to 180, and the share of financial contributions by industry members continued to increase. For the first five CCDSs, established by the Office of Commercial Programs in 1985, the ratio of private-to-government support is now approximately 3:1.

NASA initiated the CCDS program to attract a broad U.S. industry involvement. The centers represent consortia of university, industry, and government involved in early research and testing stages of potentially viable products or services.

A CCDS Management Operations Working Group was established last year by OCP and the group functioned effectively in 1989, serving as a coordinating body for collaborative efforts and program planning.

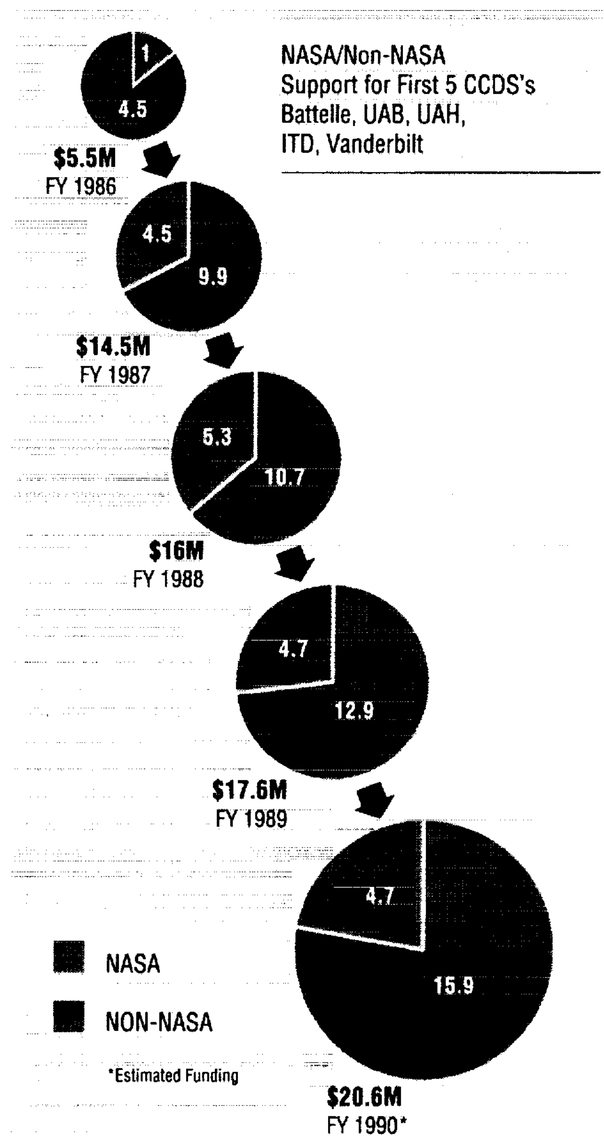
Among the most significant CCDS achievements of 1989 were:

- Spaceflight experiments coordinated and conducted by the Center for Macromolecular Crystallography (University of Alabama–Birmingham) and the Consortium for Materials Development in Space (University of Alabama–Huntsville).
- The development of a stronger, more efficient power supply through a collaborative effort by the Center for Commercial Development of Space Power (Auburn University) and Maxwell Laboratories, San Diego, California.

While conducting research into space power equipment, the research team identified potential commercial applications to existing terrestrial markets. The advance, already being marketed by Maxwell, represents the first technology spinoff by a NASA CCDS.

- The initiation by the Space Vacuum Epitaxy Center (University of Houston) of a hardware development project to build a wake shield facility to enable commercial research in a high ultra-pure vacuum during Space Shuttle flights.

Centers for the Commercial Development of Space (CCDS)Funding Leverages (Dollars in Millions)



Satellite pictures of Earth, like this false-color image of a frontier basin in Asia, help Unocal scientists identify deposits of oil and gas. Unocal is working with NASA to advance its use of remote sensing technology.

Above: A Space Shuttle external tank, photographed after it was jettisoned during the flight of STS-29. The University Corporation for Atmospheric Research (UCAR) plans to use up to five ETs for conducting experiments during their suborbital flight.

Right: Artist concept of the wake shield facility deployed on the end of the remote manipulator arm.

New Cooperative Agreements

NASA in 1989 expanded its partnership with U.S. industry through the signing of cooperative agreements providing support for industrial space research, commercial space transportation, and the private development of space infrastructure and services.

Commercial launch vehicle agreements were signed with Martin Marietta, enabling the firm to gain access to payload processing facilities at the Kennedy Space Center; LTV Missile and Electronics Group, granting the firm exclusive rights to commercially produce and market the Scout launch vehicle; and with Conatec, of Lanham, Maryland, facilitating the firm's use of NASA launch facilities at Wallops Island, Virginia.

A Memorandum of Agreement (MOA) was signed with the University Corporation for Atmospheric Research (UCAR), Boulder, Colorado, establishing the terms and conditions for use of the Space Shuttle's external tanks for suborbital experiments. Completed in December 1988, the agreement will make available to UCAR the use of up to five designated external tanks.

A Memorandum of Understanding (MOU) signed with the Coca-Cola Company will support the firm's investigation of fluid dynamics, gas-liquid separation, and metering technologies in space.

NASA also signed a Memorandum of Understanding (MOU) with Corabi International Telemetrics, Inc., a Maryland-based telemedicine systems company, supporting the commercial development of telemedicine services for the Space Station *Freedom.*

In addition to these signed agreements, a number of candidate Joint Endeavor Agreements and Space System Development Agreements were identified during 1989.

Among the companies discussing potential cooperative agreements with NASA is Unocal (Union Oil of California), already engaged in a commercial remote sensing project under a Proprietary Work Agreement with Stennis Space Center.

Genentech, a biotechnology firm which is working in collaboration with the Center for Cell Research (Pennsylvania State University) and signed this year a Technical Exchange Agreement with NASA's Ames Research Center, is also discussing other potential cooperation.

Biocryst, a Birmingham, Alabama, firm, is seeking to commercialize technologies being developed by the Center for Macromolecular Crystallography.

NASA uses a number of innovative and functional agreements that provide industry with assistance, services, and facilities to help reduce the risks associated with commercial space ventures.

Joint Endeavor Agreements (JEA) involve no exchange of funds and are designed to encourage private companies to conduct space research and development leading to new products and services. Private industry funds the experiments and NASA provides transportation and other services.

Space Systems Development Agreements (SSDA) provide industry with a deferred payment schedule for Space Shuttle launch services. This allows a new commercial space venture to have a more favorable cash flow during a time when capital investment costs are typically the greatest.

Technical Exchange Agreements (TEA) are designed for companies interested in commercial applications but not yet ready to commit to specific spaceflight experiments or ventures. Under this agreement, NASA and a company agree to exchange technical information and cooperate in the conduct and analysis of ground-based research programs.

Other agreements, such as Memoranda of Understanding and Memoranda of Agreement, provide a framework for meeting other commercial interests in cooperation with NASA.

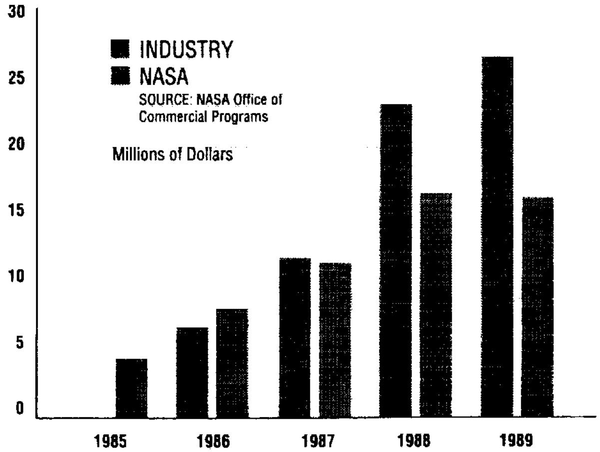
Commercial Space Involvement of Fifty Largest U.S. Industrial Corporations

		Agreements	CCDS Affiliations
1	GENERAL MOTORS		1
2	FORD MOTOR		
3	EXXON		
4	INTERNATIONAL BUSINESS MACHINES		1
5	GENERAL ELECTRIC		1
6	MOBIL		
7	CHRYSLER		
8	TEXACO		
9	E.I. DU PONT DE NEMOURS		3
10	PHILIP MORRIS		
11	CHEVRON		
12	AMOCO		1
13	SHELL OIL		
14	OCCIDENTAL PETROLEUM		
15	PROCTER & GAMBLE		1
16	UNITED TECHNOLOGIES	TEA	0
17	ATLANTIC RICHFIELD		
18	EASTMAN KODAK		1
19	BOEING	JEA, OTHER	5
20	RJR NABISCO		
21	DOW CHEMICAL		1
22	XEROX		
23	USX		
24	TENNECO		
25	MCDONNELL DOUGLAS	MOA	4
26	PEPSICO		
27	WESTINGHOUSE ELECTRIC		3
28	ROCKWELL INTERNATIONAL	JEA, CPAC	6
29	ALLIED-SIGNAL		
30	DIGITAL EQUIPMENT		1
31	PHILLIPS PETROLEUM		1
32	GOODYEAR TIRE & RUBBER		1
33	LOCKHEED		3
34	MINNESOTA MINING & MANUFACTURING	JEA,CPAC*	0
35	CATERPILLAR		
36	SARA LEE		
37	WEYERHAEUSER		
38	UNISYS		
39	HEWLETT-PACKARD		
40	ALUMINUM CO. OF AMERICA		
41	GENERAL DYNAMICS	MOA	1
42	INTERNATIONAL PAPER		1
43	GEORGIA PACIFIC		
44	CONAGRA		
45	JOHNSON & JOHNSON		
46	ANHEUSER-BUSCH		
47	UNOCAL	CPAC	0
48	SUN		
49	COCA-COLA	MOU	0
50	UNION CARBIDE		

KEY
* CPAC Member retired from Corporation
JEA: Joint Endeavor Agreement
MOU: Memorandum of Understanding
CPAC: Commercial Programs Advisory Committee
CCDS: Center for the Commercial Development of Space
TEA: Technical Exchange Agreement
MOA: Memorandum of Agreement

Source: *Fortune*, "The Fortune 500", April 24, 1989 and NASA Office of Commercial Programs

NASA and Industry Support for the Centers for the Commercial Development of Space



In 1989, NASA's Technology Utilization Division continued to open new avenues for the transfer of NASA-developed technologies to the public and private sectors.

By participating in a number of new cooperative ventures and implementing new initiatives, NASA's nationwide technology transfer network has been further strengthened and expanded.

In addition, the division has taken an active role in national efforts aimed at helping to regain America's industrial competitive strength by increasing federal technology transfer activities and improving coordination among the government agencies involved.

As a proactive force in technology utilization for more than 26 years, NASA's Technology Utilization Division has helped to promote and facilitate the transfer of literally thousands of NASA spinoffs.

These spinoffs, in areas as diverse as medicine and transportation, have generated a multitude of social and economic benefits for the entire nation to reap.

Technology Utilization — A National Priority

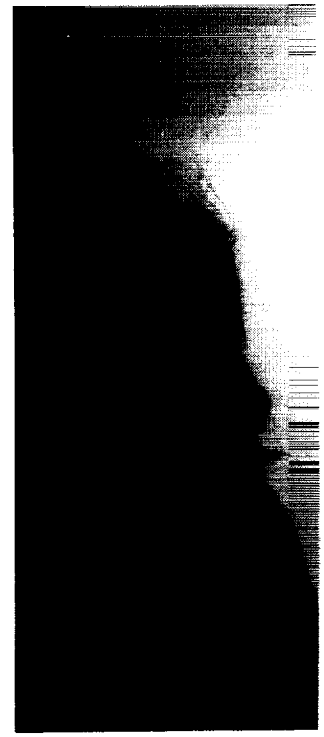
Shortly after his inauguration, President Bush urged Americans to "take actions today that will ensure a better tomorrow. We must extend American leadership in technology, increase long-term investment, improve our educational system, and boost productivity. These are the keys to building a better future."

The President's comments not only echoed the concerns of a nation, but also form the basis of recent legislative and executive directives concerning technology transfer.

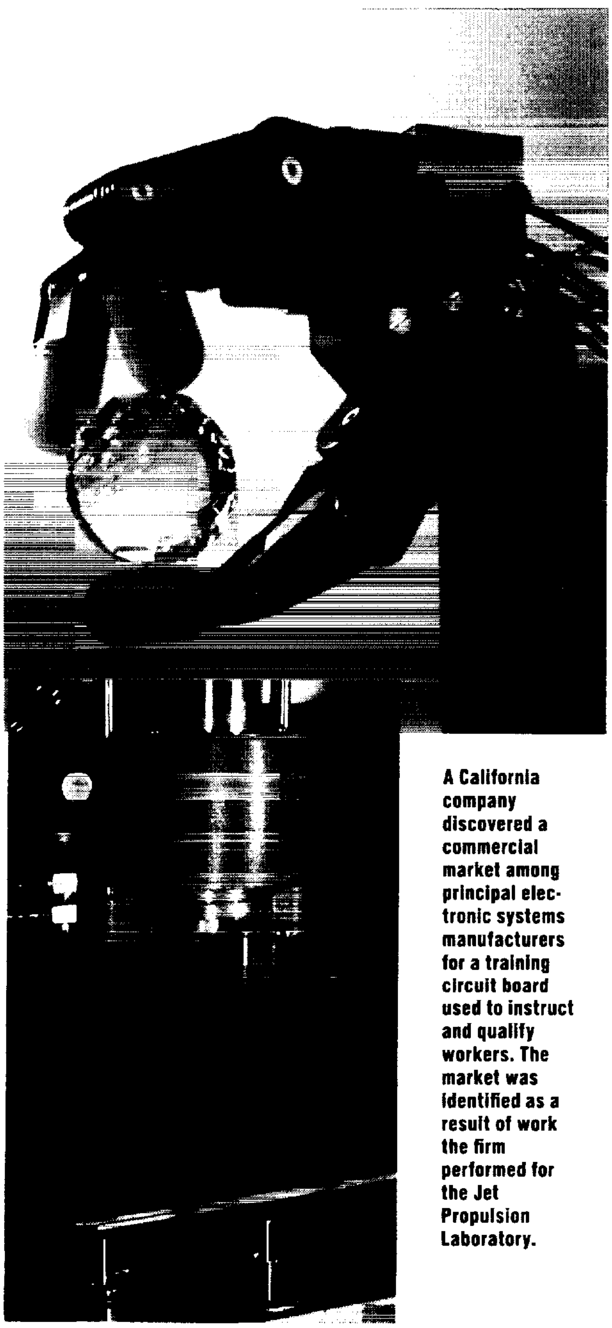
The failure of many U.S. firms to capitalize on the research and technologies generated in federal programs is widely viewed as a major factor in the U.S.'s declining global marketplace position.

In an effort to bridge this critical gap, NASA has continued to review and strengthen its own technology utilization program, comply quickly with specific directives, and work closely with other organizations.

In 1989, the agency began implementation of a new strategic plan, which serves as a guideline for NASA technology tranfers. The plan was formulated following a thorough review of the program in 1988.



A demonstration at MIT's Artificial Intelligence Laboratory shows use of a prototype robot hand, developed as a result of a NASA program to promote advancements in the development of dextrous telemanipulators for space and industrial applications.



A California company discovered a commercial market among principal electronic systems manufacturers for a training circuit board used to instruct and qualify workers. The market was identified as a result of work the firm performed for the Jet Propulsion Laboratory.

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NASA was also the first federal agency to distribute its patent royalty income as required by Public Law 99-502. On June 3, 1988, checks totaling $56,944 were issued to 35 current and former NASA employee-inventors.

The checks paid the inventor's share of NASA's patent royalty income received between the effective date of the Federal Technology Transfer Act of 1986 (October 20, 1986) and December 31, 1987. Some $61,000 in royalties received during 1988 are currently being distributed.

In addition, NASA responded to a mandate from congressional conferees of the Committees on Appropriations aimed at coordinating federal technology transfer efforts by providing industry with a single point of contact.

The mandate directed NASA's Office of Commercial Programs to "conduct a definition/design study of the five-year master plan for the establishment of a national repository for federal research and development (technology transfer), which would be located in West Virginia. . . ." Five-year cost estimates and a proposal for cost sharing were also requested.

NASA assigned preparation of the study to the Technology Utilization Division, which in turn formed a task team of technology transfer experts to assist with the effort.

Following the development of a preliminary National Technology Transfer Center design, the task team solicited comments from representative federal agencies involved in the technology transfer process.

The incorporation of these inputs helped produce a plan that promises significant benefits for the public and private sectors. The plan was submitted to the Committees on Appropriations in the House of Representatives and Senate on February 1, 1989.

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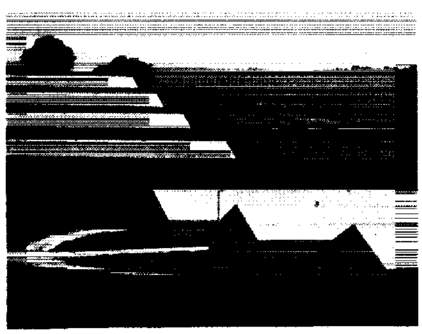


Advanced computer software developed by NASA and available through NASA's Computer Software Management and Information Center (COSMIC), has been used widely by U.S. industry. Structural design and analysis software has, for example, been employed by Chrysler Corp. in automobile engineering, and by the University of Georgia Agricultural Engineering Department, seeking to improve poultry facilities for the benefit of Georgia's billion-dollar-a-year poultry industry.

Another initiative underway involves transferring what NASA has learned about space-related science, engineering, and technology to our nation's school systems.

Under the proposed effort, the feasibility of producing a high-school textbook or textbooks is being investigated. The textbook could be offered to the public sector for licensing and publishing and subsequently be available for use in high schools across the country.

It is hoped that the availability of such a textbook would facilitate a dramatic increase in the number of high-school space science classes offered, sparking the interest and imaginations of America's students and encouraging them to pursue science and engineering studies at the university level.

An Expanded TU Network

New links to public and private-sector groups in 1989 have helped to enhance both the size and scope of NASA's nation-wide technology transfer network, as well as to fulfill national economic objectives.

With the addition of seven new affiliates, the network now extends into 40 states across the country.

Through a variety of mechanisms, the network allows NASA to move information into the private sector and to assist in its application.

A recent agreement with the Center for New West (CNW) will link the NASA network to CNW members and affiliates in eighteen western states.

CNW is a nonprofit policy research organization committed to understanding America's emerging new economy, promoting economic growth in the western U.S., and improving the competitiveness of western enterprise in the world marketplace.

A Memorandum of Understaning (MOU), signed by NASA and CNW, will provide a vehicle for the exchange of information, dissemination of research results, and development of joint projects.

Major agreements between NASA field centers and five states are expected to enhance NASA's technology transfer efforts, as well as impact favorably on the economic activities of each state.

The MOUs, signed by NASA and the states of Alabama, West Virginia, Tennessee, Virginia, and Florida, were negotiated by NASA Field Center Technology Utilization Officers and are expected to lead to new joint endeavors.

In addition, a cooperative venture between NASA and the state of California is expected to help advance research in the highly dynamic research area of superconductivity.

Recognizing that superconductivity technologies promise to play an important role in the future of California industry and NASA missions, the two parties are cosponsoring a pilot Superconductivity Applications Center. The project will consist of a technical program and center related activities.

Under the technical program, which will be sponsored primarily by the state of California, NASA's Jet Propulsion Laboratory and the California Institute of Technology will work on four superconductivity-related research tasks in cooperation with TRW and Rockwell International.

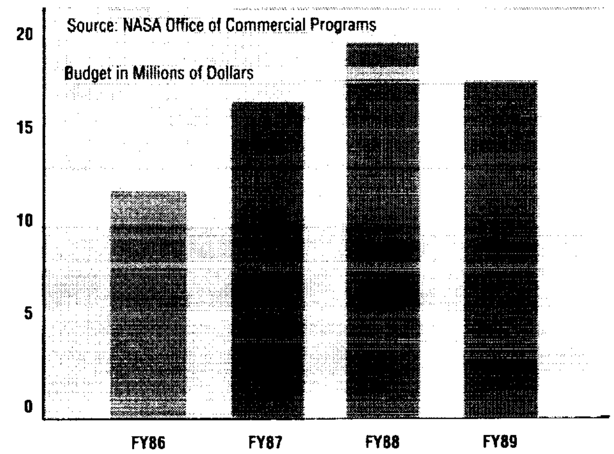
Center related activities will be sponsored by NASA and will include program management, program analyses and integration, and center design and development.

The Technology Utilization Division is also working closely with the Department of the Navy to assist in development of a Navy Technology Transfer Center.

The Navy is interested in identifying state-of-the-art technology available in industry, academia, and other government agencies, and in bringing it into Navy repair and maintenance facilities to solve critical problems.

Under the initiative, NASA's Industrial Applications Centers (IACs) will work on a number of Navy projects, evaluating problems, assessing potential solutions, and recommending courses of action. The Navy has transferred initial funding for the effort to NASA and is currently prioritizing projects and holding discussions with various IACs.

OCP Budget for Technology Utilization
(Current Dollars)



NASA's AdaNet program is currently in Phase II of its implementation plan. The AdaNet Software Repository is intended to be a self-supporting commercial organization to provide users of Ada with information sharing and depository services.

ORIGINAL PAGE
COLOR PHOTOGRAPH

It will operate on a for-profit basis and is targeted to become self-sustaining through client income by 1991.

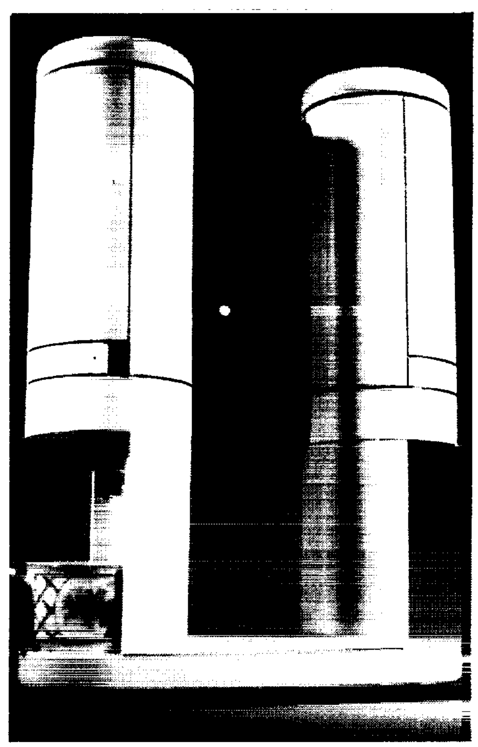
NASA is also planning to enhance the capabilities of field center technology utilization offices through implementation of a microcomputer-based system that efficiently stores data and facilitates timely access to new technologies developed in NASA programs.

This system will complete the linkage of NASA technology utilization field installation offices, COSMIC, the NASA Scientific and Technical Information Facility, and IACs to provide a quicker distribution of new technologies than had been previously possible.

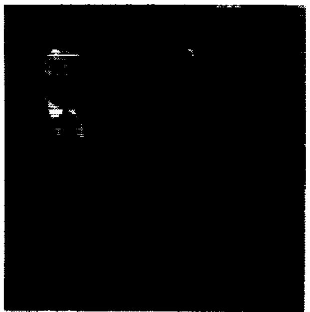
Application Efforts

NASA's direct support of technology application efforts in 1989 helped to produce advances in fields ranging from medicine to transportation. Some 80 application projects are currently being conducted at nine NASA field installations.

House Subcommittee on Space Science and Applications conducts hearing on the technology spinoffs from the space program.



***NASA Tech Briefs* magazine reaches more than 100,000 subscribers annually. Elan, Inc., a California firm, discovered a NASA-patented device designed by an astronaut to produce brewed coffee in space. Obtaining a license to commercialize the device, Elan has developed and is now marketing this new coffee maker.**



At an April hearing of the House Subcommittee for Space, Science, and Applications, numerous commercial applications of NASA-developed technologies were described by company and university officials representing a diverse array of fields.

The witnesses recounted a number of "success stories" in which NASA application projects had resulted in social and economic gain.

One of the projects described at the hearing was the Sterling engine. The Sterling is an external combustion engine that, when compared with conventional internal combustion engines, offers a number of unique advantages. It is a high-torque engine that operates at a constant speed. It uses one spark plug, needs no muffler, emits no noxious gas, and can use fuel of any kind.

In addition to use in vans and trucks, the engine is also being considered for irrigation pumping and mobile processing in agriculture, drying proceses in the lumber industry, and for use on trawlers, dredges, and shrimp boats in the fishing industry.

A multi-year, multi-phase demonstration program has been created by an industry/government team to obtain early operation and performance data; evaluate integrity, reliability, and durability; and accelerate development.

Given its many advantages and versatility, the Sterling engine may have profound impacts on both the transportation and processing industries.

A major advance in diabetes control has resulted from another application project.

Known as the Rechargeable Physiologic Sensor, an implantable device is being developed that promises to free one million Type 1 insulin dependent diabetics, in the U.S. alone, from numerous daily finger-prick blood tests required to monitor glucose levels.

The device will also provide a more accurate analysis of glucose levels. Researchers expect a prototype sensor to be completed by the end of 1989 and predict that a commercial unit could be in the marketplace within four years.

Application projects are geared toward the solution of public and private sector problems that have been identified by user organizations. Direct NASA assistance and primary funding are provided.

They involve cooperative efforts to build and test prototype hardware if the industrial partner agrees to provide partial funding and is prepared to complete marketing of the transfer.

Two application teams, Research Triangle Institute and Rural Enterprises, Inc., are presently operating. The teams broker industrial clients' needs and match such needs with NASA technology. In FY 1990, NASA will continue to broaden application team responsibilities.

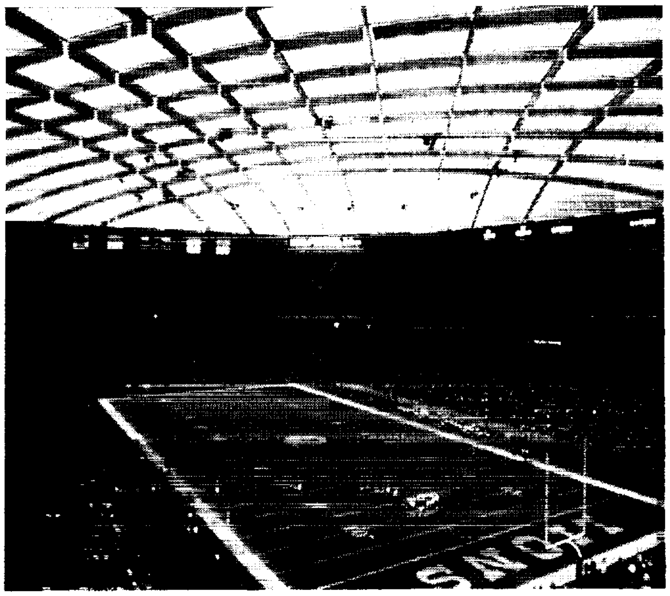
Increasing Visibility

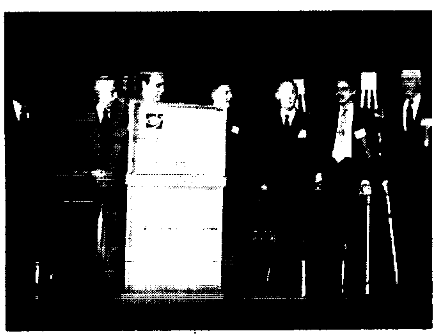
NASA's technology transfer efforts have received increased media attention, with articles on the subject appearing in national publications and numerous radio and television broadcasts focusing on NASA spinoffs.

The 20th anniversary of Apollo 11 this year resulted in an extraordinary level of interest in the spinoffs associated with America's effort to land the first men on the Moon.

In addition, the scope and circulation of *NASA Tech Briefs* and *Spinoff* publications continues to grow. *Tech Briefs*, which identifies new technologies developed in NASA programs, is presently receiving 1,500 inquiries per day for more detailed information on specific technologies.

Likewise, NASA's annual *Spinoff* continues to report new applications of NASA-developed technologies.





Special fabric developed in the 1960s for spacesuits provided the basis for material used later in construction-grade fabrics. The first adaptation of this technology was in Michigan's Silverdome. NASA technology utilization managers and the team of individuals credited with the application of space technology to use in fabric structures are recognized at this year's Spinoff Hall of Fame ceremony in Colorado Springs, Colorado.

Twenty years ago: Man on the Moon.

An Exploration of Benefits

A contracted study to assess the economic impacts of NASA technology transfer was completed this summer, resulting in new findings that indicate substantial financial benefits to U.S. business.

Entitled An Exploration of Benefits From NASA *"Spinoff,"* the study was conducted by the Chapman Research Group, Inc., of Littleton, Colorado.

The research determined the estimated revenues and cost-savings derived from a sample of applications reported in NASA's *Spinoff* publication.

More then 400 applications reported in the magazine between 1978 and 1986 were traced. It was found that 342 applications resulted in acknowledged contributions to sales or savings. Of these, about 75 percent, or 259 cases, permited some quantification of sales or savings. The 259 applications were determined to have contributed to the sales of new or improved products in the amount of $21.3 billion and contributed to savings of nearly $316 million.

It was also calculated that the revenues produced through the estimated sales generated federal income tax revenues of nearly $356 million. Additionally, 352,000 jobs were projected to have been created, or retained due to the increased revenues (not savings) attributed to these spinoffs.

This study continues to identify the enormous social and economic benefits generated by NASA's technology transfer efforts.

Because it concentrates on a few applications and measures only some of the quantitative benefits derived from those applications, the study may reveal only a fraction of the real value stemming from the "spinoff" of NASA technology.

Honoring Apollo-Era Spinoffs

This year marked the 20th anniversary of the U.S. space program's greatest triumph: the first human footsteps on the Moon.

At special events in Washington, D.C., and Paris, the astronaut crew of Apollo 11 recalled the historic flight, and shared with national leaders and citizens of the world a perspective on that achievement of July 20, 1969.

In May, the U.S. Space Foundation honored three technology spinoffs that resulted directly from the program to land Americans on the Moon.

The organization hosted a special ceremony in Colorado Springs, Colorado, its headquarters, to recognize the individuals and organizations instru-

NASA's Technology Transfer System

mental in the adaptation of Apollo technology for use in:

- Cordless Tools, developed by Black and Decker as a derivative of specialized tools used by the Apollo astronauts to collect lunar samples.
- Scratch Resistant Lenses, which use the technology developed for protecting the reflective visors on the astronaut's helmet.
- Fabric Structures, like the covering over the Silverdome football stadium in Pontiac, Michigan. The fabric used in such construction is a derivative of the Apollo spacesuit material.

These three technologies, inducted into the U.S. Space Foundation's Spinoff Hall of Fame, represent but a few of the thousands of technology applications to be spun off from the Apollo program.

The national commitment to land U.S. astronauts on the Moon and return them safely to Earth spurred major advances in emerging technologies, such as computers, which became smaller, lighter, and more efficient, to meet the requirements for manned spacecraft. Today, twenty years after Apollo 11's "giant leap for mankind," the technology that enabled that achievement continues to enhance our lives on Earth through uses in fields such as health, safety, recreation, manufacturing, transportation, and energy.

△ **Field Center Technology Utilization Officers:** manage center participants in regional technology utilization activities.

● **Industrial Applications Centers:** provide information retrieval services and assistance in applying technical information relevant to user needs.

○ **Industrial Applications Centers Affiliates:** state-sponsored business or technical assistance centers that provide access to NASA's technology transfer network.

■ **The Computer Software Management and Information Center (COSMIC):** offers government-developed computer programs adaptable to secondary use.

▲ **Application Team:** works with public agencies and private institutions in applying aerospace technology to solution of public problems.

During 1989 the NASA Small Business Innovation Research Program (SBIR) received a substantial increase in funding. This, along with wider understanding of the opportunities offered by SBIR, resulted in a large increase in small, high-technology business participation in the program.

NASA's SBIR program, now entering its seventh year, implements the Small Business Innovation Development Act of 1982. The legislation requires government agencies with research and development (R&D) budgets exceeding $100 million to set aside 1.25 percent of their annual R&D appropriations for the award of Phase I and Phase II SBIR contracts. Eligibility requirements for small businesses and program implementation guidelines for all participating agencies are provided by the Small Business Administration.

SBIR program objectives established by law include stimulating

Benefits Realized From NASA-Furnished Technology Case Applications From *Spinoff*

(Reports By Categories of End Use Sales or Savings, Thousands of Dollars*)

END USE DESCRIPTION	NUMBER OF CASES	NUMBER OF CASES WITH SALES OR SAVINGS	BENEFITS SALES	REALIZED SAVINGS	$(000) TOTAL
Communi-cation/Data Processing	51	32	171,007	51,964	222,971
Energy	30	13	203,500	15,613	219,113
Industrial (mfg & process)	170	107	5,767,649	67,837	5,835,486
Medical	61	31	2,003,036	30,613	2,033,649
Consumer Products	24	18	1,278,294	524	1,278,818
Public Safety	27	16	347,888	555	348,443
Transportation	40	18	9,887,865	116,623	10,004,488
Environmental	16	11	16,962	21,788	38,750
Other	22	13	1,654,989	10,232	1,665,221
Total	**441**	**259**	**$21,331,190**	**$315,749**	**$21,646,939**

*Estimates were obtained from company officials, or derived from company estimates of manpower or other types of savings (see Appendix A, Study Approach and Conduct). The 441 cases were reported in *Spinoff* magazine, 1978-86; of these 368 had acknowledged sales or savings, but 109 cases could not be estimated as to extent.

NASA SBIR Program Award Statistics

	PHASE I			PHASE II			PHASE I & II
PROGRAM SOLICITATION YEAR	PROPOSALS	AWARDS	TOTAL FUNDING SM	PROPOSALS	AWARDS	TOTAL FUNDING SM	TOTAL PROGRAM FUNDING SM
1983	977	102	5.0	92	58	24.0	29.0
1984	919	127	6.3	113	71	32.5	38.8
1985	1164	150	7.4	129	84	39.3	46.7
1986	1628	172	8.5	154	85	39.2	47.7
1987	1826	204	10.0	179	100	47.9	57.9
1988	2379	228	11.3	NA	NA	NA	NA
TOTALS TO DATE	**8893**	**983**	**48.5**	**667**	**398**	**182.9**	**220.1(1)** **231.4(2)**

NOTE: (1) Total Program Funding Shown is for First Five Program Solicitation Years
(2) Total Program Funding Shown is for First Five Program Solicitation Years, Plus 1988 Phase 1

technological innovation in the private sector, strengthening the role of small businesses in federal R&D programs, fostering and encouraging greater participation of minority and disadvantaged persons in technological innovation, and increasing private sector commercialization of innovations derived from federal R&D.

A recent survey conducted by NASA of completed SBIR projects indicated that all these objectives are being achieved and that the program has become a highly regarded element of NASA's overall R&D activities. An assessment of the SBIR program conducted by the General Accounting Office concurred with NASA's findings.

The NASA survey found that the results of more than half the SBIR projects reviewed have already been incorporated or will soon be incorporated into NASA mission programs and that many projects have substantially advanced the technology base in several areas. The survey revealed that the quality of research conducted in SBIR projects was as high or higher than comparable research funded through other R&D means, and that at least one-fourth of the projects had already resulted in commercial products or enterprises by the small businesses.

NASA data also indicate that a substantial number of minority and disadvantaged firms have won SBIR contracts for high-technology projects.

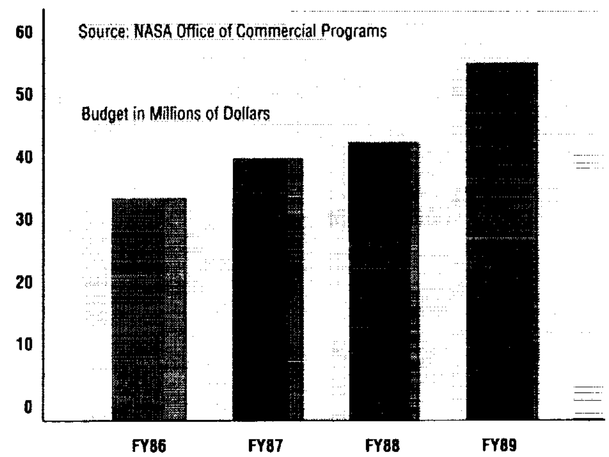
Program Elements

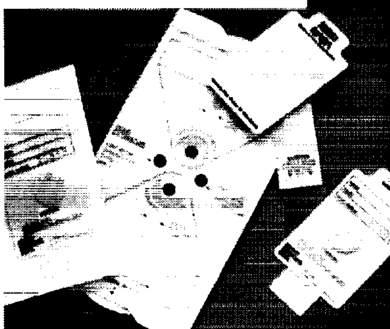
The SBIR program consists of three distinct phases. Phase I objectives are to establish the feasibility of innovative concepts proposed by small businesses to meet NASA program objectives, solve problems, or exploit new technological opportunities. Phase I projects are completed in six months and are funded up to $50,000.

Phase II is the principal SBIR activity, in which more than half of the Phase I projects are more fully developed. Phase II projects may be funded up to $500,000 and may take up to two years to complete.

In Phase III, the small firm uses private sector capital to commercialize its SBIR project result, to sell its product or service to a government agency or contractor, or to obtain government support for further R&D. Phase III may not employ SBIR set-aside funding.

OCP Budget for Small Business Innovation Research
(Current Dollars)





GMD Systems of Hendersonville, Pennsylvania, under contract to NASA's Kennedy Space Center, developed a badge for monitoring workers' exposure to the toxic propellant hydrazine.

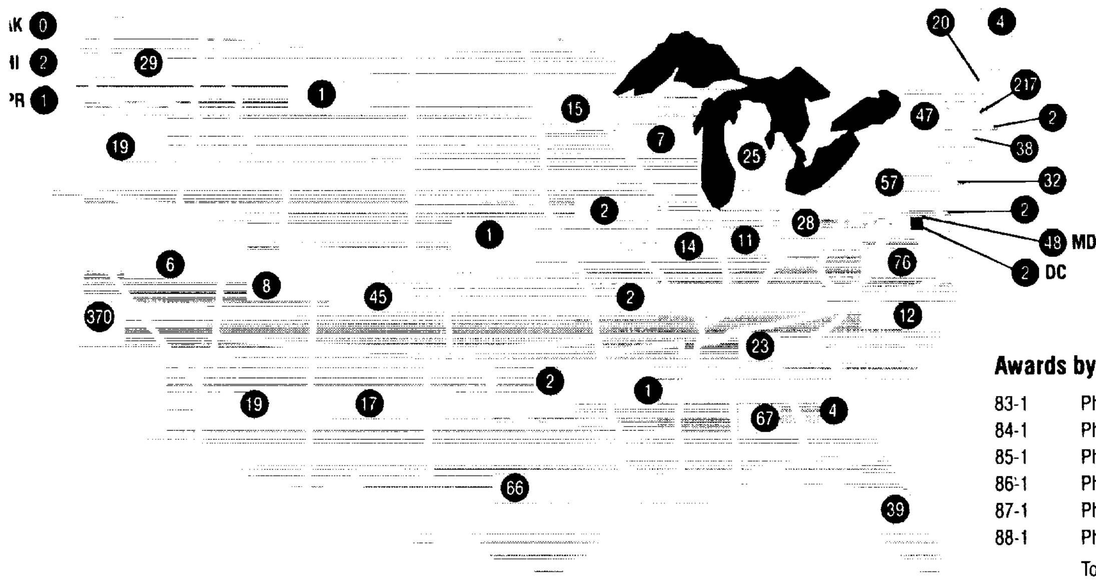
Through an SBIR contract with NASA's Johnson Space Center, Houston, BoMed Medical Manufacturing Ltd., an Irvine, California, firm, developed a non-invasive heart monitor that has been incorporated into a commercially successful system.

FY 1989 SBIR Activities

SBIR activities during FY 1989 included the selection of 228 Phase I awards from the nearly 2,400 proposals submitted in response to the 1988 Program Solicitation. During 1989, 100 Phase II awards were made for further development of Phase I projects initiated during 1988. The 1989 SBIR program was initiated with the issuance of the 1989 SBIR solicitation. Other activities included program outreach and efforts to foster commercialization of SBIR results.

NASA's 1989 SBIR Program Solicitation invited Phase I proposals in fifteen areas of technology subdivided into 150 specific subtopics. Nearly 25,000 copies of the solicitation were distributed, and by its closing on June 28, more than 2,140 Phase I proposals had been received. Those found responsive to the solicitation were distributed to the nine NASA field centers for technical evaluation. It is planned that at least 225 Phase I awards will be announced in early FY 1990.

SBIR outreach activities in 1989 included participation in more than a dozen conferences and seminars aimed at assisting small businesses in understanding the NASA SBIR program. In an effort to anticipate and encourage winning companies to develop the commercial potential of SBIR results, the SBIR Office has initiated a program to follow and report on projects as they proceed. Other efforts



Awards by Program Year

83-1	Phase I & II	(160)
84-1	Phase I & II	(199)
85-1	Phase I & II	(234)
86-1	Phase I & II	(256)
87-1	Phase I & II	(304)
88-1	Phase I	(228)
	Total	1381

have centered on strengthening ties with NASA's network of Industrial Application Centers and Centers for the Commercial Development of Space to foster technology transfer and commercial application of technology developed under NASA R&D programs.

SBIR Projects

Two projects that began in 1985 illustrate the impact and value of SBIR projects both to NASA and to the nation.

BoMed Medical Manufacturing Ltd. of Irvine, California, received a contract through Johnson Space Center to develop a continuous, non-invasive means to monitor bloodflow through the heart and thereby assess the heart's condition. The company delivered a successful device now being used in research on the effects of weightlessness on astronauts.

The company sold a version of this monitor for use in hospital operating rooms and intensive care units and invested in the development of a comprehensive system for non-invasive hemodynamic and cardiodynamic patient monitoring and therapeutic management. In 1988 it launched its new system. Revenues have increased seven-fold since 1984, and the company is now profitable. BoMed attributes much of its success in this field to the opportunity provided by SBIR.

GMD Systems, Inc., of Hendersonville, Pennsylvania, has been working with the Kennedy Space Center to develop a badge that will measure a worker's exposure to hydrazine. Hydrazine is an extremely toxic fuel with various applications, including use in the Space Shuttle's Orbital Maneuvering Vehicle.

The badge monitors a worker's cumulative exposure by changing color and responds to the current permissible exposure limit for hydrazine in as little as 15 minutes. This will allow employees to evacuate a contaminated work zone before hydrazine has accumulated to dangerous levels.

Because this is the first hydrazine detector to measure personal exposure levels, the firm expects there to be a significant market wherever it is used, whether in spacecraft, missiles, boiler cleaning, or fertilizer production.

Future Focus

Based on the FY 1990 budget request, the NASA SBIR budget is expected to exceed $60 million, from which NASA anticipates considerable growth in the numbers of SBIR contracts awarded and of small businesses participating in NASA's R&D programs.

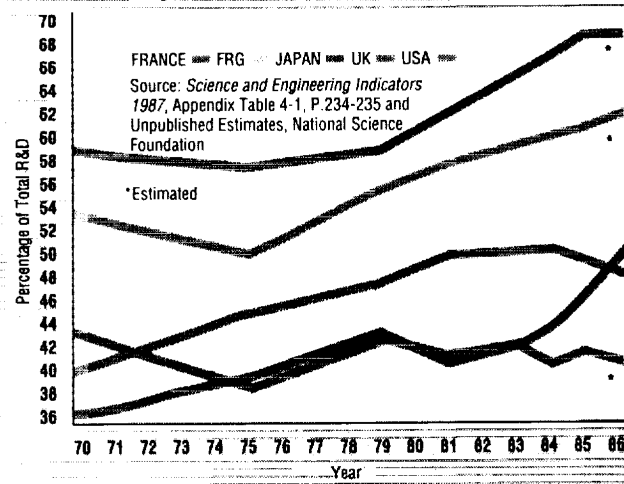
Efforts to promote commercial development of SBIR project results will continue to focus on disseminating project results more widely and developing linkages between the SBIR program and the NASA Industrial Application Network, the Small Business Development Centers, and the Centers for the Commercial Development of Space.

International and Domestic R&D Trends

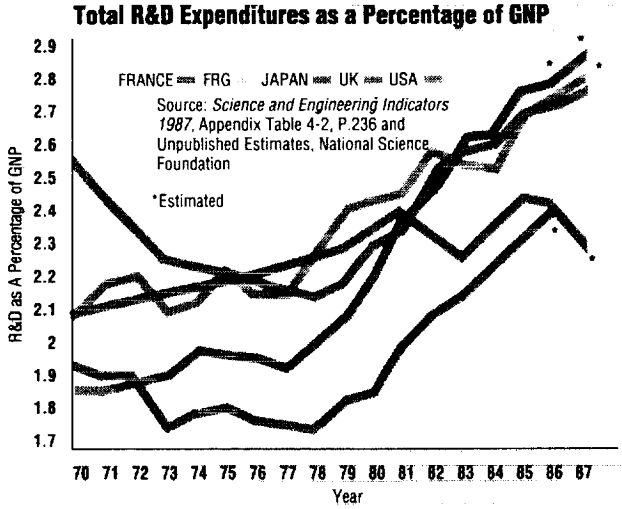
The charts and graphs included in this section characterize key international and domestic trends in research and development expenditures. International comparisons focus on spending by major U.S. trading partners who are also active in space research and commercial applications.

Space sector data demonstrate the commercial space interests of leading U.S. industrial corporations, the contribution of the high-technology aerospace industry to the U.S. balance of trade, and information on the emerging commercial launch vehicle industry and its competitive position.

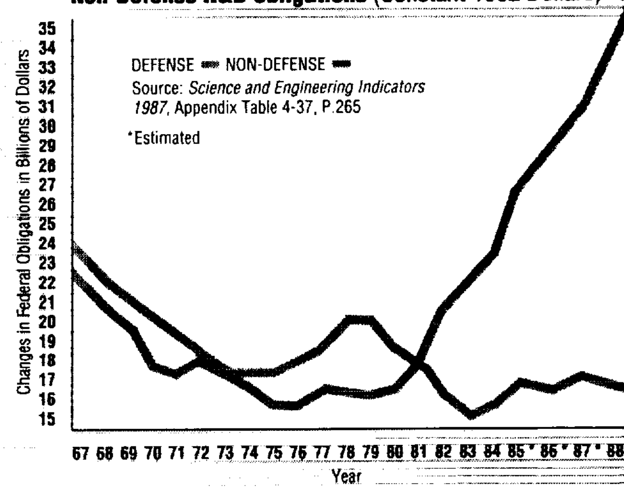
Percentage of Total R&D Expenditures Funded by Business



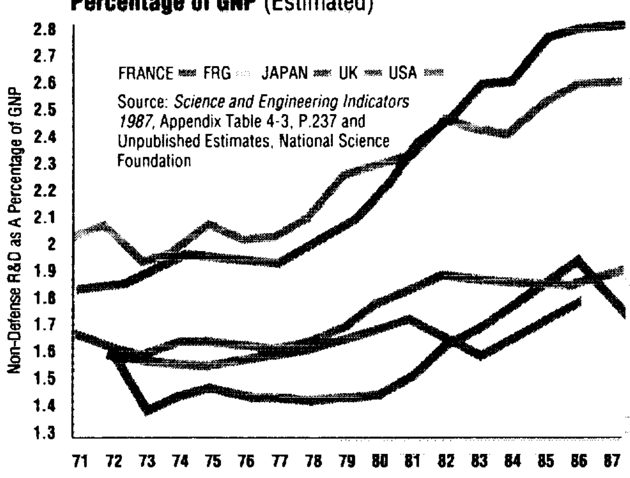
Total R&D Expenditures as a Percentage of GNP



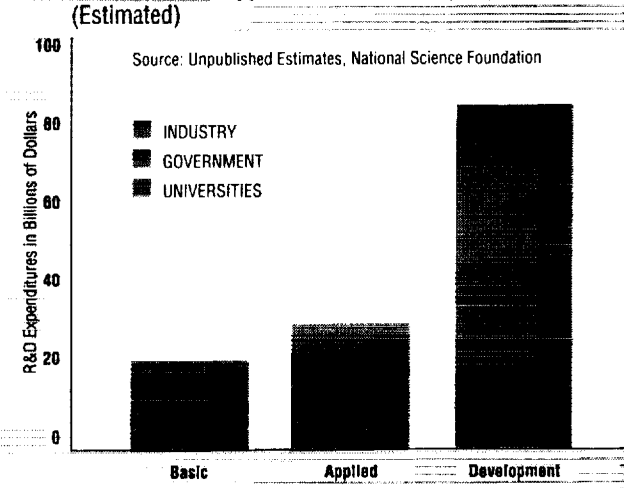
Relative Changes in Federal Defense and Non-Defense R&D Obligations (Constant 1982 Dollars)



Non-Defense R&D Expenditures as a Percentage of GNP (Estimated)

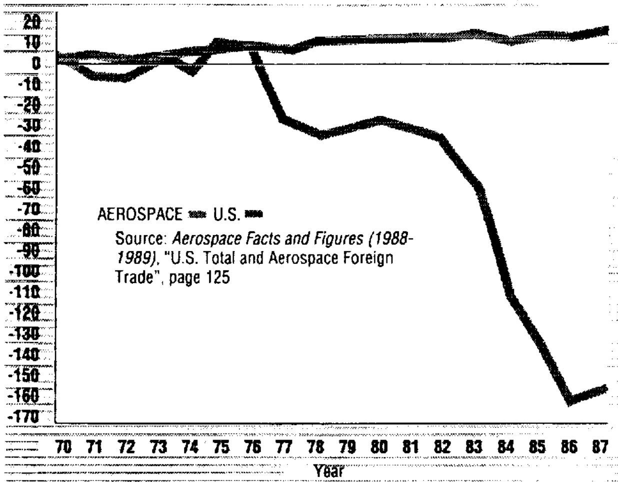


U.S. Basic and Applied R&D by Sector, 1988 (Estimated)



Space Sector

Aerospace Balance of Trade Verses Overall U.S. Balance of Trade, 1970 - 1987 (Current Dollars)

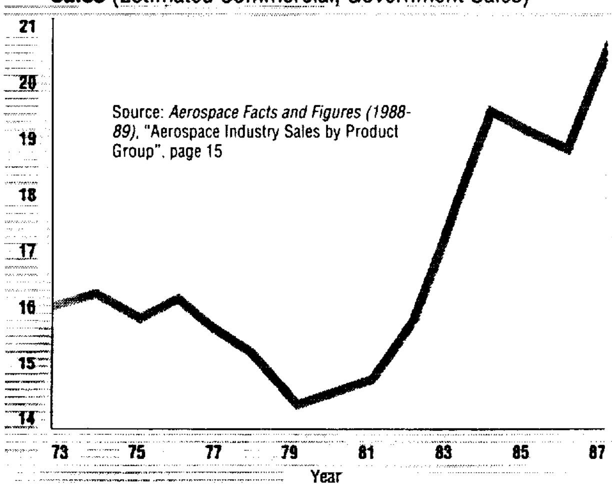


Government Civil Space Applications Budgets
(Approximate)

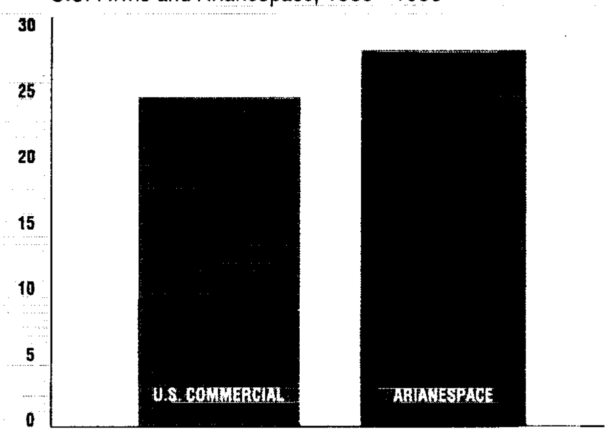
Entity	Satellite Communications		Remote Sensing		Materials Processing	
	1983/84	1987	1983/84	1987	1983/84	1987
ESA	222	249	41	198	75	39
FRANCE	53	105	92	120	8	14
WEST GERMANY	100	30	5	8	22	32
JAPAN	73	109	66	99	9	14
CANADA	33	36	35	43	N/A	N/A
TOTAL	480	529	239	468	114	99
U.S.A.	32	100	15	24	22	35

SOURCE: *U.S. Civil Space Program: An AIAA Assessment*, March 1987, AIAA

Space Product Sales as a Percentage of Aerospace Sales (Estimated Commercial, Government Sales)

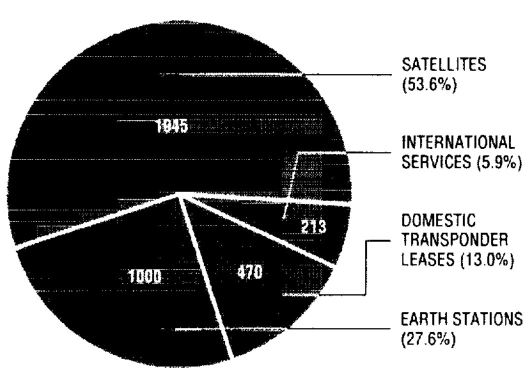


Commitments to Launch Satellites
U.S. Firms and Arianespace, 1989 - 1993



Source: *U.S. Commercial Launch Manifest*, June 1989, Department of Transportation and *Ariane Launch Manifest*, July 1988 and March 1989, Arianespace, Inc.

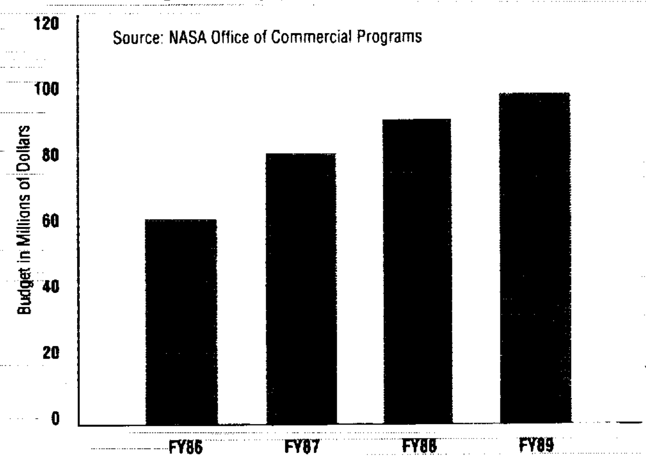
Communications Satellite Revenues
(Estimated, Millions of Dollars, by Market, 1986)



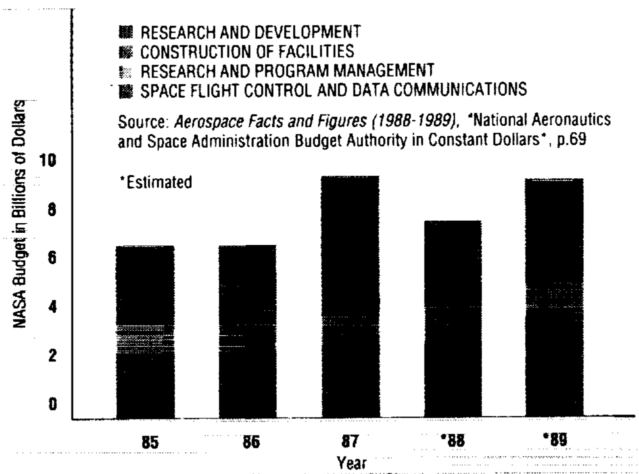
Source: Space Market Model, Space Business Information Center, August 1988

Presented in this section are the budget history of the Office of Commercial Programs, a review of the overall NASA budget trend, and economic impacts attributed to NASA funding.

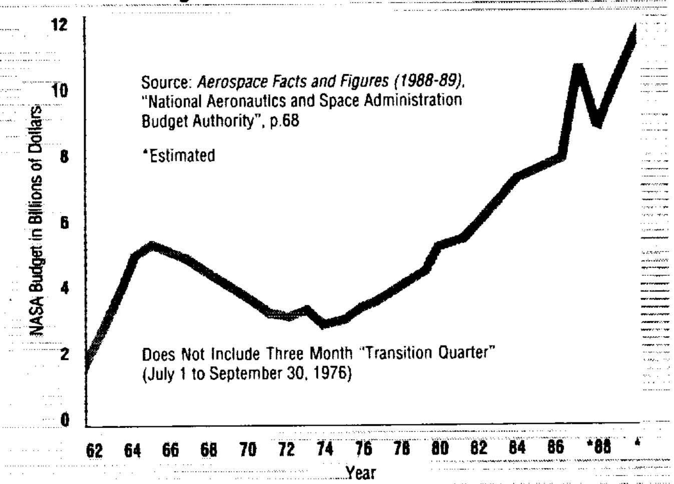
OCP Budget History (Current Dollars)



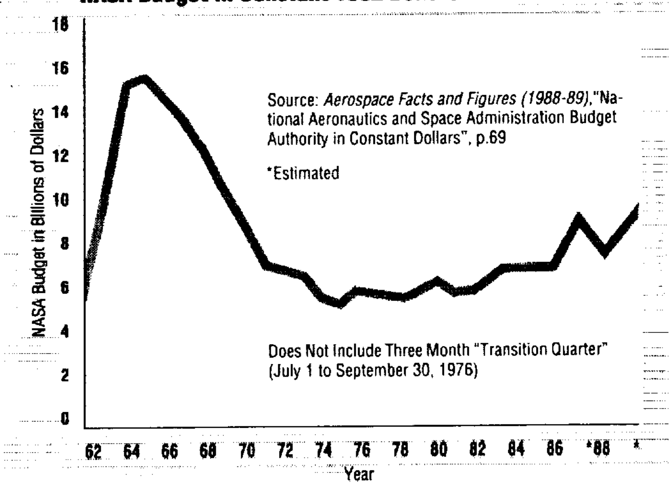
NASA Budget Breakdown by Function (Constant 1982 Dollars)



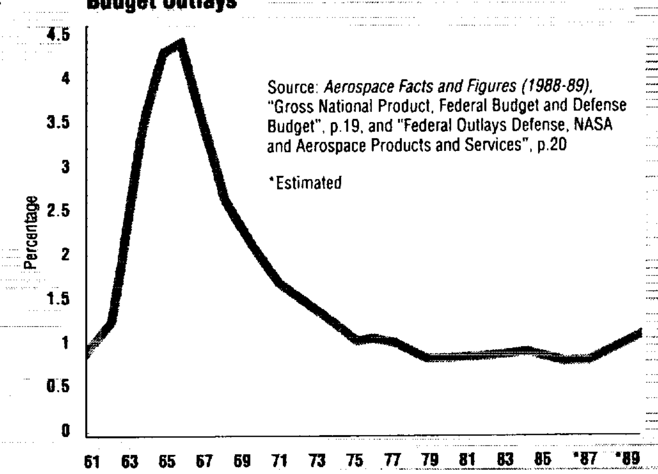
NASA Budget in Current Dollars



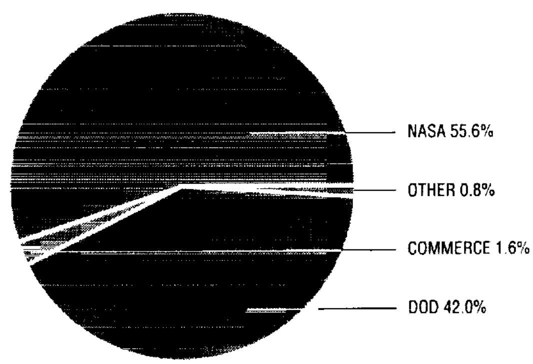
NASA Budget in Constant 1982 Dollars



NASA Budget Outlays as a Percentage of Federal Budget Outlays

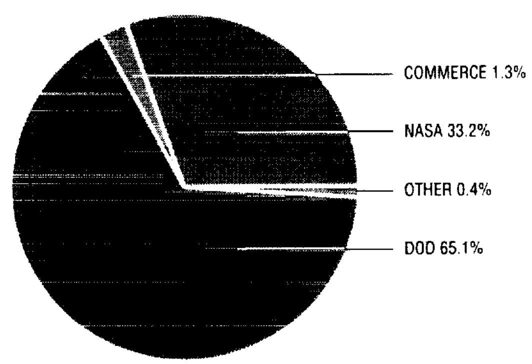


U.S. Space Spending by Department, 1978
(Millions of Current Dollars, Estimated)



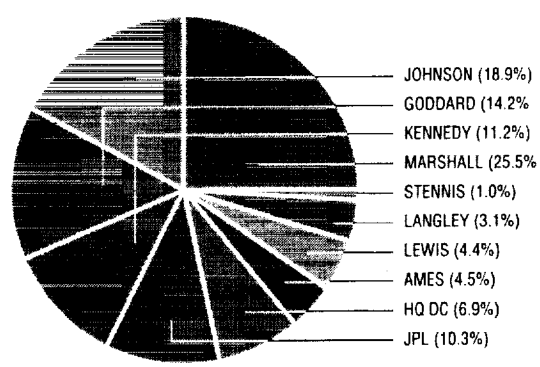
Source: *Aerospace Facts & Figures (1988-1989)*, "Federal Space Activities Budget Authority", p.66

U.S. Space Spending by Department, 1988
(Millions of Current Dollars, Estimated)



Source: *Aerospace Facts & Figures (1988-1989)*, "Federal Space Activities Budget Authority", p.66

NASA Procurement by Center
(Fiscal Year 1988, Estimated)



Source: *NASA Pocket Statistics, January 1989*, "Total Procurement by Installation", p.C-4, "Employment Summary", p.C-26

NASA Procurement and Employment by Center, FY88

	PROCUREMENT ($Millions)	EMPLOYMENT*	
		Federal Employees	**Support Contractors**
MARSHALL SPACE FLIGHT CENTER	2428	3429	1231
JOHNSON SPACE CENTER	1806	3498	8590
GODDARD SPACE FLIGHT CENTER	1356	3727	3300
KENNEDY SPACE CENTER	1069	2330	9364
NASA RESIDENT OFFICE/JPL	986	5628	
LEWIS RESEARCH CENTER	418	2716	1246
HEADQUARTERS	661	1829	809
AMES RESEARCH CENTER	432	2169	1928
LANGLEY RESEARCH CENTER	297	2966	1720
STENNIS SPACE CENTER	92	159	1213

*As of September 30, 1988

Source: *NASA Pocket Statistics*, January 1989, "Total Procurement by Installation", p.C-4, "Employment Summary", p.C-26

States in Which NASA Procurements Created Over 1000 Jobs (Estimated Direct and Indirect Effects on Employment, FY87)

	Employment (Number of Jobs)
CALIFORNIA	63612
TEXAS	17094
FLORIDA	13462
MARYLAND	10342
ALABAMA	7457
OHIO	7264
NEW YORK	6728
VIRGINIA	5962
CONNECTICUT	5452
UTAH	5330
PENNSYLVANIA	5111
COLORADO	4876
NEW JERSEY	4810
ILLINOIS	4801
LOUISIANA	3929
MICHIGAN	3727
MASSACHUSETTS	3719
MISSOURI	2829
GEORGIA	2743
INDIANA	2695
WASHINGTON	2669
ARIZONA	2111
NORTH CAROLINA	2096
TENNESSEE	1903
MISSISSIPPI	1858
WISCONSIN	1736
MINNESOTA	1550
KANSAS	1383
KENTUCKY	1165
OKLAHOMA	1100
NEW MEXICO	1090

Source: Management Information Services Inc., 1988

States in Which NASA Procurements Generated Over $100 Million in Sales (Estimated Direct and Indirect Economic Effects, FY87)

	Sales ($Millions)
CALIFORNIA	5219.5
TEXAS	1653.8
FLORIDA	996.7
MARYLAND	756.5
OHIO	707.7
ALABAMA	633.9
NEW YORK	543.0
VIRGINIA	481.3
PENNSYLVANIA	460.3
CONNECTICUT	457.4
UTAH	455.9
LOUISIANA	426.4
ILLINOIS	420.5
MICHIGAN	388.9
NEW JERSEY	385.5
COLORADO	379.5
MASSACHUSETTS	290.4
INDIANA	263.1
MISSOURI	260.5
WASHINGTON	235.9
GEORGIA	228.2
MISSISSIPPI	178.7
ARIZONA	176.1
NORTH CAROLINA	174.6
TENNESSEE	158.9
WISCONSIN	149.4
KANSAS	132.6
OKLAHOMA	127.2
MINNESOTA	126.8
KENTUCKY	110.5
NEW MEXICO	108.1

Source: Management Information Services Inc., 1988

States in Which NASA Awarded Over $1 Million in Contracts, FY1988 (Businesses, Educational Institutions, and Non-profits))

	Contract Awards ($Millions)
CALIFORNIA	2411.4
TEXAS	913.1
FLORIDA	873.4
MARYLAND	661.3
ALABAMA	547.8
UTAH	429.2
LOUISIANA	332.2
VIRGINIA	318.3
OHIO	159.6
NEW JERSEY	112.3
PENNSYLVANIA	105.1
COLORADO	86.6
MISSISSIPPI	85.0
CONNECTICUT	76.1
MASSACHUSETTS	64.0
DISTRICT OF COLUMBIA	56.7
NEW YORK	55.0
NEW MEXICO	45.6
WISCONSIN	32.4
TENNESSEE	21.5
ARIZONA	21.1
KANSAS	20.7
MICHIGAN	17.6
WASHINGTON	17.5
GEORGIA	15.7
ILLINOIS	15.2
MISSOURI	13.4
INDIANA	11.7
MINNESOTA	9.0
IOWA	7.9
NEW HAMPSHIRE	7.4
HAWAII	6.9
NORTH CAROLINA	6.2
DELAWARE	3.6
OKLAHOMA	3.4
OREGON	2.9
ALASKA	2.8
RHODE ISLAND	2.5

Source: *NASA Pocket Statistics*, January 1989, "NASA Contract Awards by State", p.C-4

Commercial Programs Management

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LAWRENCE F. HERBOLSHEIMER *Deputy Assistant Administrator*

J. MICHAEL SMITH *Deputy Assistant Administrator* (Program Development)

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HENRY J. CLARKS *Director,* Technology Utilization Division

HARRY W. JOHNSON *Director,* Small Business Innovation Research Division

DR. BARBARA STONE *Director,* Plans, Policy, and Evaluation Division

THOMAS D. BROWN *Director,* Program Support Division

Commercial Programs Advisory Committee

In July 1988, the Commercial Programs Advisory Committee (CPAC) was formally created to provide NASA with a diverse, high-level industry viewpoint on commercial space business.

As a subcommittee of the NASA Advisory Council, the group was chartered to assist NASA by reviewing policies and programs, and by recommending strategies to implement national space policy goals.

Committee members were drawn from the ranks of U.S. corporate chief executives and their university counterparts.

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